The secondary organs of the immune system form an interconnected surveillance system where the immune cells gather and exchange information. The lymph, lymphoid vessels, and lymph nodes are a critically important part of this system. Circulation among the organs includes both lymph and blood. The blood makes a round trip, while the lymph makes a one-way trip from the organs out. So, here we have blood moving immune cells throughout the body. The blood has many different types of cells, proteins, including antibodies, clotting proteins, complement, and other things that attack foreign cells. The plasma from the blood filters into the tissues carrying the proteins, and so, generally, only the lymphoid cells crossover, not the red blood cells, not most of the myeloid cells. So, here we see the one-way pick-up from the lymph system. It's going through the lymph nodes, and then, back up into the heart. Here we have a classic diagram of the overall lymphatic system picking up fluid throughout the body. This drained interstitial fluid from tissues, which is picking up antigens, white blood cells, debris from infections, and all other kinds of information, is going to be gathered up and filtered through the lymph nodes, where the antigen is trapped and acted on. Eventually, these vessels grow into larger ones that empty into the thoracic duct, which in turn empties into the left subclavian vein, and then, enters the heart so it will rejoin the blood circulation. This is a classical drawing of this system, and it's the one that you will find in most textbooks. However, it doesn't show anything in the head. Just in the last couple years, scientists have found that the lymph system does indeed extend into the head. It's called the meningeal system. We now know that the head is indeed brain and specifically under immune surveillance. So, here we have a collecting vessel that runs over the top of the head, and it connects with the deep cervical or neck lymph nodes. This thing lies between the dura mater and the meninges outside the brain and between the meningial arteries and the dural sinuses, which are the veins. So, here we have the sagittal sinus over the top of the head, we have the transverse sinuses running along the side, and buried in there is a lymph vessel, which scientists managed to miss entirely until about two or three years ago. So, we'll see it will divide into two transverse branches, and then, the valves it has are only those that are in the skull. So, it is a little different from the rest of the system. Here's another view. This is a view of something where somebody basically peeled the top off a mouse brain, not human, just a mouse, or depending on how you feel. It shows the sinuses and the lymph vessels, that is, this is the sagittal, these are the transverse. So, this gives you a different view of how these are connected up. Then, of course, they lead out to the cervical lymph nodes. Here we have a picture of the vessels, and here's a picture of the vessel. This is an electron micrograph. It shows the vessels, and also shows, if you'll see, the red dots are T cells. We can see that indeed this part of the body is getting immune surveillance. So, back to the lymph nodes again. Here is a drawing of the axillary lymph nodes that is in the armpit. I picked this one in particular because it numbers and names the various lymph nodes that are likely to be monitored in case somebody has a metastasized breast cancer. I would never expect you to memorize this. This is just a bit of extra resource for you. So, here is the anatomy of one of those lymph nodes. You can see we've got fluid coming in from the outside. So, this is where the tissues drain into that lymph node. They will drain in, and fluid cells, what have you, will pass through. They will come out the efferent vessel, and eventually, they will join up and wind up in the subclavian vein. So, another view of this. We look at this vessel. This is the cortex or outermost part. It holds the follicles and the B cells. It is underlain by the structure called the power cortex. That just means the one underneath. We have the medulla here that shows you the interior part of the lymph node. Now, mature B cells leave through this, interacting with T cells on the way out. So, they're going to start in at the top with a fluid, they're going to interact at the outer surface, and then, they're going to eventually make their way out into the rest of the body. So, B cells that are activated by antigen are going to wind up in follicles. The follicles are in the cortical region of these lymph nodes. So, here is a follicle, you can see this one here. See it has a lighter region, and then, a darker region on the outside. Some B cells will enter this follicle, which develops basically after antigen exposure. The light part in the middle is the active germinal center. The B cells are going to develop there in response to signals from the follicular dendritic

cells, Th cells, and then, macrophages will clean up the debris. So, if a B cell has spent time in a secondary follicle, it is in there learning to make an antibody that binds more tightly to the particular pathogenic antigen. So, that follicle function will also be found in the other two secondary lymphoid organs, which we're going to look at next.